ILRS SLR MISSION SUPPORT REQUEST FORM (version: January 2018)

SUBMISSION STATUS:

(●) New Submission (default)

( ) Incremental Submission (accepted only for a follow-on mission; fill-in new information only)

(provide the reference mission and the date approved by the ILRS: ________________________)

SECTION I: MISSION INFORMATION:

General Information:

Satellite Name: LARES 2 (LAser RElativity Satellite 2)

Satellite Host Organization: Italian Space Agency - ASI

Web Address: www.asi.it

Contact Information:

Primary Technical Contact Information:

Name: Prof. Antonio Paolozzi

Organization and Position: Sapienza University of Rome, School of Aerospace Engineering. Associate Professor

Address: Via Salaria 852, 00138 Rome, Italy

Phone No.: +39 3666750165

E-mail Address: antonio.paolozzi@uniroma1.it

Alternate Technical Contact Information:

Name: Dr. Claudio Paris

Organization and Position: Centro Fermi. Researcher

Address: Piazza del Viminale 1, 00184 Rome, Italy

Phone No.: (+39) 3332028137

E-mail Address: claudio.paris@centrofermi.it

Primary Science Contact Information:

Name: Prof. Ignazio Ciufolini

Organization and Position: Università del Salento, Dipartimento di Ingegneria dell'Innovazione. Associate Professor

Address: Centro Ecotekne Pal. O - S.P. 6, Lecce - Monteroni - LECCE (LE), Italy

Phone No.: (+39) 380 3070772

E-mail Address: ignazio.ciufolini@gmail.com, ignazio.ciufolini@unisalento.it

Alternate Science Contact Information:

Name: Dr. Giuseppe Bianco

Organization and Position: Italian Space Agency, ASI. Responsible of Space Geodesy Operative Unit.

Address: Centro di Geodesia Spaziale "Giuseppe Colombo", Località Terlecchia snc, 75100 Matera (MT), Italy

Phone No.: (+39) 0835377509; mobile: (+39) 320 8579369

E-mail Address: giuseppe.bianco@asi.it

Mission Specifics:

Scientific or Engineering Objectives of Mission:
(specify)

LARES 2 will achieve important measurements in gravitational physics, General Relativity, space geodesy and geodynamics, in particular, together with the LAGEOS, LAGEOS 2 and LARES satellites and with the GRACE models, it will provide a very accurate determination of the Earth gravitomagnetic field and of the Lense-Thirring effect.

Role of Satellite Laser Ranging (SLR) for the Mission:
(specify)

Key role.

Anticipated Launch Date: June 2020

Expected Mission Duration: Decades

Required Orbital Accuracy: < 1 cm CEP for weekly arc

Anticipated Orbital Parameters:

Altitude (Min & Max for eccentric orbits): 5899 km

Inclination: 70.16 degrees

Eccentricity: between 0 and 0.0025

Orbital Period: 13500 s

Frequency of Orbital Maneuvers: N.A.

Mission Timeline:
(example)
Should include when SLR is to start within the mission timeline, such as "on insertion into orbit" or "launch +N" days.

SLR is to start on insertion into orbit

Tracking Requirements:

Tracking Schedule: ◉ horizon-to-horizon ○ custom (specify: ______)

Spatial Coverage: ◉ global ILRS network ○ custom (specify: ______)

Temporal Coverage: ◉ full-time ○ custom (specify: ______)

Normal Point Bin Size (Time Span): 120 seconds

(Choose one from 5, 15, 30, 120 and 300 seconds. Justify if other bin size is required.)
(See the "Bin Size" of other satellites on the ILRS Web site at *http://ilrs.gsfc.nasa.gov/missions/satellite_missions/current_missions/index.html* .)

Prediction Center: Sapienza Università di Roma

Prediction Technical Contact Information:

Name: Ignazio Ciufolini

Organization and Position: Università del Salento, Dipartimento di Ingegneria dell'Innovazione. Associate Professor

Address: Centro Ecotekne Pal. O - S.P. 6, Lecce - Monteroni - LECCE (LE), Italy

Phone No.: (+39) 380 3070772

E-mail Address: ignazio.ciufolini@gmail.com, ignazio.ciufolini@unisalento.it

Priority of SLR for POD: ◉ Primary ○ Secondary ○ Backup

Other Sources of POD:

☐ GNSS ☐ DORIS ☐ Accelerometer ☐ other (specify: ______)

Other comments on mission information:

(specify) (list backup prediction centers and references/links to non-SLR techniques if available)

SECTION II: TRACKING RESTRICTIONS:

Several types of tracking restrictions have been required during some satellite missions. See *http://ilrs.gsfc.nasa.gov/satellite_missions/restricted.html* for a complete discussion.

1) Elevation restrictions: Certain satellites have a risk of possible damage when ranged near the zenith. Therefore a mission may want to set an elevation (in degrees) above which a station may not range to the satellite.
2) Go/No-go restrictions: There are situations when on-board detectors on certain satellites are vulnerable to damaged by intense laser irradiation. These situations could include safe hold position or maneuvers. A small ASCII file is kept on a computer controlled by the satellite's mission which includes various information and the literal "go" or "nogo" to indicate whether it is safe to range to the spacecraft. Stations access this file by ftp every 5-15 minutes (as specified by the mission) and do not range when the flag file is set to "nogo" or when the internet connection prevents reading the file.
3) Segment restrictions: Certain satellites can allow ranging only during certain parts of the pass as seen from the ground. These missions provide station-dependent files with lists of start and stop times for ranging during each pass.
4) Power limits: There are certain missions for which the laser transmit power must always be restricted to prevent detector damage. This requires setting laser power and beam divergence at the ranging station before and after each pass. While the above restrictions are controlled by software, this restriction is often controlled manually.

Many ILRS stations support some or all of these tracking restrictions. You may wish to work through the ILRS with the stations to test their compliance with your restrictions or to encourage additional stations that are critical to your mission to implement them.

The following information gives the ILRS a better idea of the mission's restrictions. Be aware that once predictions are provided to the stations, there is no guarantee that forgotten restrictions can be immediately enforced.

Are there any science instruments, detectors, or other instruments on the spacecraft that can be damaged or confused by excessive radiation, particularly in any one of these wavelengths (532nm, 1064nn, 846nm, or 432nm)?

◉ No ○ Yes (specify the instrument or detector in question, providing the wavelength bands and modes of sensitivity.)

Are there times when the LRA (Laser Retroreflector Array) will not be accessible from the ground?

◉ No ○ Yes (specify: ____________________________

(If so, go/nogo or segmentation files might be used to avoid ranging an LRA that is not accessible.)

→ Skip the next questions and go directly to SECTION III if you answered "No" to both of the above questions.

Is there a need for an elevation tracking restriction?

○ No ○ Yes (What elevation (minimum to maximum in degrees)? _________ degrees)

Is there a need for a go/no-go tracking restriction?

○ No ○ Yes (Explain the reason(s) ____)

Is there a need for a pass segmentation restriction?

○ No ○ Yes (Explain the reason(s) ____)

Is there a need for a laser power restriction?

○ No

○ Yes (Under what circumstances? ____)

(What is the maximum permitted power level **at** the satellite (nJ/cm^2)? __________)

(Is manual control of laser transmit power acceptable? ○ Yes ○ No)

For ILRS stations to range to satellites with restrictions, the mission sponsor must agree to the following statement:

"The mission sponsor agrees not to make any claims against the station or station contractors or subcontractors, or their respective employees for any damage arising from these ranging activities, whether such damage is caused by negligence or otherwise, except in the case of willful misconduct."

Please provide signature to express agreement to above statement:

Signature: ____

Date: ____________________________

Name (print): ____

Organization and Position: ____

Other comments on tracking restrictions:
(specify)

SECTION III: RETROREFLECTOR ARRAY INFORMATION:

A prerequisite for accurate reduction of laser range observations is a complete set of pre-launch parameters that define the characteristics and location of the LRA on the satellite. The set of parameters should include a general description of the array, including references to any ground-tests that may have been carried out, array manufacturer and whether the array type has been used in previous satellite missions. So the following information is requested:

Retroreflector Primary Contact Information:

Name: Dr. Claudio Paris

Organization and Position: Centro Fermi. Researcher

Address: Piazza del Viminale 1, 00184 Rome, Italy

Phone No.: (+39) 3332028137

E-mail Address: claudio.paris@centrofermi.it

Array type:

○ Single reflector ⦿ Spherical ○ Hemispherical/Pyramid ○ Planar

○ other (specify: ________________)

Attach a diagram or photograph of the satellite that shows the position of the LRA, at the end of this document.

☒ Attached

Attach a diagram or photograph of the whole LRA at the end of this document.

○ Attached ⦿ Same as above, Not attached (acceptable only for a cannonball satellite)

Array manufacturer:

Edmund Optics

Link (URL and/or reference) to any ground-tests that were carried out on the array:

https://www.lares-mission.com/LARES_2.asp

Has the LRA design and/or type of cubes been used previously?

⦿ No ○ Yes (List the mission(s): ________________)

For accurate orbital analysis it is essential that full information is available in order that the 3-dimensional position of the satellite center of mass may be referred to the location in space at which the laser range measurements are made. To achieve this, the 3-D location of the LRA phase center must be specified in a satellite-body-fixed reference frame with respect to the satellite's mass center. In practice this means that the following parameters must be available at 1 mm accuracy or better.

Define the satellite-body-fixed XYZ coordinates (i.e. origin and axes) on the spacecraft:
(specify) (add a diagram in the attachment)

LARES 2 satellite has been designed as a sphere with a radius of 212 mm, fully covered by 303 CCRs with front face diameter of 25.4 mm (1 inch). Tolerance between CoG and geometrical center of the satellite is of 0.2 mm; the sphere has a 0.05 mm sphericity tolerance.

Relate the satellite-body-fixed XYZ coordinates to a Celestial/Terrestrial/Solar Reference Frame including the attitude control policy:
(specify) (add a diagram in the attachment)

The 3-D location of the satellite's mass center in satellite-body-fixed XYZ coordinates is:

- ◉ Always fixed at (0, 0, 0)
- ○ Always fixed at (__________, __________, __________) in mm
- ○ Time-varying by approximately (__________) mm during the mission lifetime.
  Will a time-variable table of the mass center location be available on the web?
  ○ No ○ Yes (URL: ____________________)

The 3-D location (or time-variable range) of the phase center of the LRA in the satellite-body-fixed XYZ coordinates:

(0 , 0 , 0) in mm

The following information on the corner cubes must also be supplied.

The XYZ coordinates referred to in the following are given in:

- ◉ Satellite-body-fixed system (same as above)
- ○ LRA-fixed system (specify below)

(specify the origin and orientation) (add a diagram in the attachment)

List the position (XYZ) of the center of the front face of each corner cube, and the orientation (two angles or normal vector) and the clocking (horizontal rotation) angle of each corner cube. Note that the angles should be clearly defined.

- ◉ Attached at the end of this document
- ○ Listed here (acceptable for small number (10 or fewer) of corner cubes) (specify) (add a diagram in the attachment)

The list of XYZ coordinates will be made available immediately after the launch.

Is the corner cube recessed in its container (i.e. can the container obscure a part of the corner cube)?

○ No ◉ Yes (specify below)

Recess of the front faces from the spherical surface is 3,32 mm, so the nominal distance of the front face from the geometrical center is 208.68 mm nominally

The size of each corner cube: Diameter (25.4) mm Height (19.05 +/- 0.25) mm

The material from which the cubes are manufactured (e.g. quartz):

Fused silica Corning 7980

The refractive index of the cube material

= 1.460710516 for wavelength $\lambda = 0.532$ micron

= n = 1.45636 @ 0.656 micron; n = 1.45846 @ 0.588 micron; n = 1.46312 @ 0.486 micron; n = 1.46669 @ 0.436 micron as a function of wavelength λ (micron):

The group refractive index of the cube material, as a function of wavelength λ (micron):

= 1.4853524 for wavelength $\lambda = 0.532$ micron

= __________ as a function of wavelength λ (micron):

Dihedral angle offset(s) and manufacturing tolerance (in arcseconds):

0” ± 1.5” (These are approximate values evaluated on 10 COTS samples).

Radius of curvature of front surfaces of cubes:

◉ Not applied ○ Yes (specify: ______________________________)

Flatness of cubes’ surfaces:

Evaluated on 10 COTS CCRs: Worse back face lambda/10, worse front face lambda/8.

Back-face coating:

◉ Uncoated ○ Coated (specify the material: ______________________________)

Other comments on LRA:

(specify) (add a reference to a study of the optical response simulation/measurement if available) (add a diagram if applicable)

The nominal CoG correction is: 174 mm +/- 2 mm

SECTION IV: MISSION CONCURRENCE

The ILRS is a voluntary organization that operates under the auspices of the International Association of Geodesy (IAG). The ILRS adheres to the IAG policy to make all acquired laser ranging data and derived products publicly available. We request that the mission website, as well as mission publications, reference the scientific work derived from ILRS data and derived products, **acknowledge** the role of the ILRS. This acknowledgment is crucial for the continued support from the funding agencies of the ILRS participating organizations.

As an authorized representative of the LARES 2 mission, I hereby request and authorize the ILRS to track the satellite described in this document.

Name (print): CLAUDIO PARIS

Organization and Position: Centro Fermi. Researcher

Signature: Firmato digitalmente da Claudio Paris
DN: cn=Claudio Paris, c=IT, o=Centro Fermi - Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi, email=claudio.paris@centrofermi.it
Data: 2019.12.05 20:43:54 +01'00'
Claudio Paris

Date: 13/02/2020

Send form to: ILRS Central Bureau
c/o Carey Noll
NASA GSFC
Code 61A
Greenbelt, MD 20771
USA
301-614-6542 (Voice)
301-614-6015 (Fax)
Carey.Noll@nasa.gov

SECTION V: ATTACHMENT(S)